DoMUS a game to communicate household energy issues in an educational context

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1. Introduction

Simulation models are often used as tools in environmental sciences. Simulation models substitute real live experiments which are hard, very expensive or impossible to carry out. This is mostly due to the possible danger, the large scale or the long time horizon. An additional advantage of simulation models is the quality to communicate complex issues, like environmental problems often are. Games, which are the extension of simulation, are even better in communication purposes.
The concept of the use of simulation models and games as a tool for communication was adapted by our institute since we got acquainted with the environmental management game: STRATAGEM, developed by Dennis Meadows in 1984 (Meadows, 1984 & 1996). The use of simulation models and games runs through our centres mission (to contribute to the environmental investigation and assessment of optional transition routes to a sustainable world) like a continuous thread.

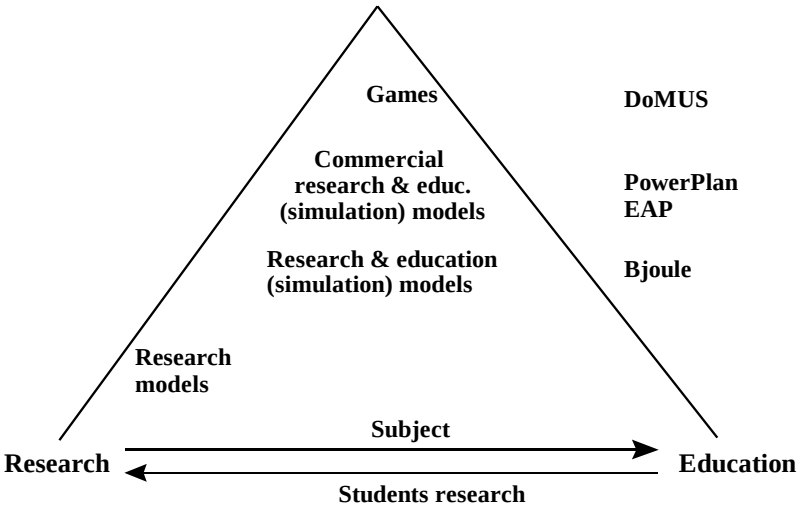

Figure 1: Model development path at the Center for Energy and Environmental Studies

The Center for Energy and Environmental Studies (IVEM) is a research as well as an educational institute. We try to incorporate the results obtained from our research programs into our environmental courses. In most cases these results will be communicated with traditional training techniques. The models developed in our research programs are used in one of our energy and environmental courses, or during a students research project. If these models can be valuable for others than our own research or student programs then a more thought-out version with manual will be developed. This process of development from research model to commercial model or

game is presented in figure 1. On the right side of the triangle some examples of models and games are given:

- ? Bjoule: educational simulation model about the transition to a sustainable energy future (Mulder, 1998 & Groenendaal, 1998);
- ? EAP: calculation model (Wilting, 1996 & 1999). EAP is a model to calculate the energy intensity (MJ/NLG), energy requirements and the greenhouse (CO_2, CH_4 and NO_x) gasses emitted to produce certain goods and services (from a bread to a car);
- ? PowerPlan: simulation model (Benders, 1989 & 1996) with which the electricity production system of a country or region can be simulated. Users have to take the seat of the central electricity board and make decisions in which kind of power plants they will invest;
- ? DoMUS: a model/game about energy consumption in households (Kok, 1999).

It speaks for itself that the choice to make a model available for others has consequences for the reliability and the user friendliness of the software.

In this paper we describe the DoMUS model. DoMUS stands for **Do**mestic **M**etabolism **U**ser friendly **S**imulated and is a result of several IVEM research projects in the nineties.
DoMUS can be used to gain insights in the energy use of households. On the one hand the model offers the possibility to determine the yearly total (direct and indirect) energy use. On the other hand it is possible to determine the consequences of a change in household expenditures. For educational purposes DoMUS is made suitable to work in two ways: as a game in which the players simulate a given household or through a guided tour.

Household energy use in DoMUS

Energy use for households can be divided in direct energy (for example needed for space heating and lighting) and indirect energy use (for example needed to produce a washing machine, grow vegetables or to deliver services). So each consumptive expenditure of a household goes with a certain energy use. The way a household spends its income determines the amount of energy used by this household. In DoMUS the household expenditures are divided into seven categories, see table 1.

Table 1: In the DoMUS the different energy consuming functions are divided into 7 categories:

category	description
space heating	energy needed to compensate transmission and ventilation losses, heating equipment;
the house itself	indirect energy for the building and insulation materials and the energy gains from solar PV and sun boilers;
apparatus	appliances for the functions: cooling, washing, dish washing, showering, cooking and lighting;
transport	all transportation's except those for holidays
food	up to 10 different options which deviate from an average meal (e.g. vegetarian);
holidays	up to 10 different types of holidays;
miscellaneous	several options in three sub categories: hobby, sport and others.

Not all national energy use flows through the households or can be imputed to the household

expenditures. This concerns energy used for e.g. the army and infrastructure. Furthermore there are expenditures which flow through the households but are difficult to impute to products or services (for example insurance's or savings).
Besides these some more expenditure categories are not present in the model, they mainly concern the indirect energy use for clothing, furniture, personal care, medical care and maintenance of the house and garden. The reason behind this selection is to obtain a balance between completeness and to much detail. So we left out those categories which do not contribute to a large extent or do not have great potentials for change in energy use as the result of a different expenditure in these categories. These choices result in that about 78% of energy consumption which flows through households and 53 % of the total Dutch energy use is covered by the DoMUS model.

The DoMUS model

The goals of DoMUS are to give insight in:

? the total energy use (direct as well as indirect) of a household;
? the relative importance of several energy consuming products and services;
? the possibilities to reduce energy use;
? the pass of energy to money, with which is meant that saving energy can also save money and the question than is what people are going to do with this 'extra' money? Will they spent it to energy extensive or energy intensive goods and services?

The user of DoMUS is confronted with the fact that only a part of the reduction of energy use in the household can be achieved by the introduction of better technologies. The other part of the reduction should come from changing habits and expenditures.

In order to adapt to a situation or target group the model can be used as a game or as a guided tour. For this *guided tour* the student sits behind a computer, a manual leads him/her through the model. The guided tour is illustrated by two fictional households. The student starts with one household and ends with the second household following the instructions in the manual. The tour is completed with some questions and exercises. In the last exercise the student has to enter his/hers own household as good as possible and he/she has to examine the possibilities to save his/hers energy consumption. This guided tour will cost a student half a day.
In the *game* option the players become member of a predefined 3 person household. In the introduction they are told that after several natural disasters the scientific community reaches consensus: global warming exists. The United Nations decides to reduce energy consumption drastically. Especially households in the western countries have to reduce their energy consumption. So the households in the game have too. All players get a general description of one of the five defined, households and a role specific description of one of the members of this household. They are ordered to reduce their energy demand to a certain level with the restriction of spending all (within 5%) their money and within the characteristics of their specific roles. During the evaluation the different types of households can be compared to show the effect of different housing, income etc. The same kind of households can be compared to show that there are often more solutions to solve the problem. This games session will take about three hours to play.

DoMUS the interface

As the acronym DoMUS suggests, we tried to develop a user friendly model. Besides an easy to use interface a short term feedback on decisions made are important. For this short term feedback the user is offered two graphs. One gives an overview of the energy used divided in the seven above described categories (see figure 2). This overview is given for the reference and the actual scenario so differences in expenditures and behaviour can immediately be compared. Between these graphs a comparison can be made for the total energy requirements (direct + indirect), for direct and indirect separately and for the costs. The comparison between the costs for both scenarios have only a relative meaning.

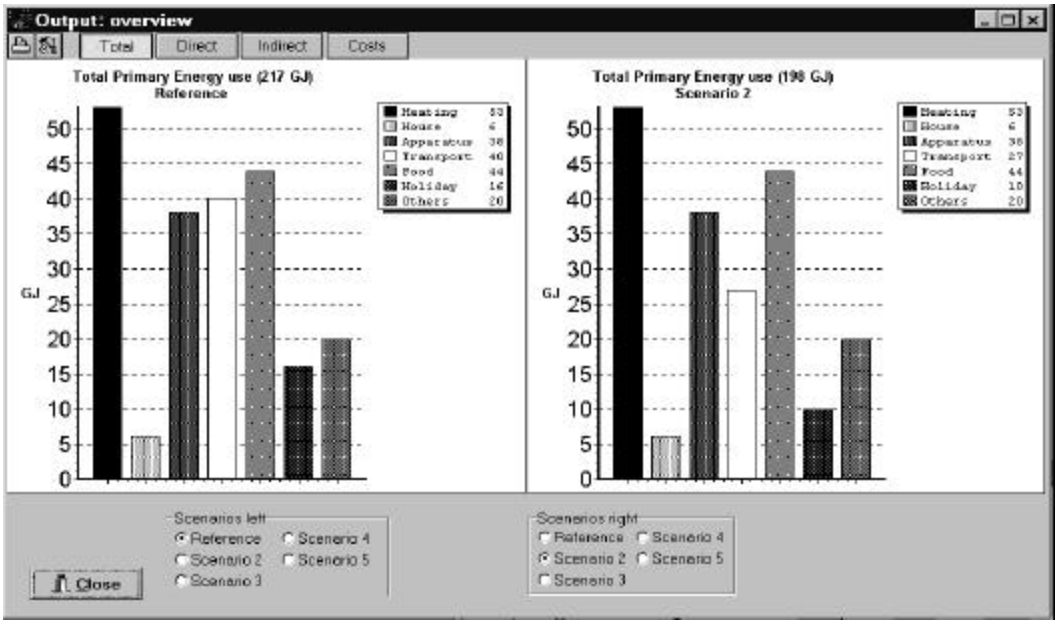

Figure 2: Overview of the costs and energy use for the seven categories

The second graph for feedback purposes shows two meters which give users (in the game mode) feedback on their target indicators. One meter gives an indication about the households budget: is

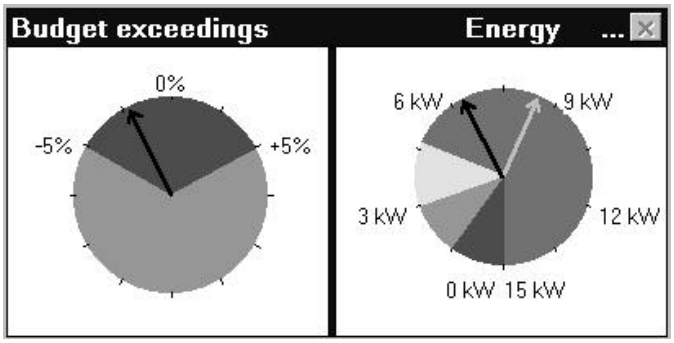

Figure 3: Budget and energy indicators

it still between the given budget boundaries of plus and minus 5%? The other meter gives an

indication of the present energy use (black arrow) in comparison with the energy use at the starting-point (grey arrow). It also shows the distance to overcome the goal to be reached (at least 3kW per person which equals in the model 80 GJ per three person household). For the guided tour a different graph with the same indicators (energy and budget) is given.

To reach the goal (game mode) or to improve your own energy use (guided tour) the user has to change his/her behaviour or his/her expenditures on the categories as defined in DoMUS. The user is offered 10 input windows, see Figure 4. The *Scenario* submenu let the user select the scenario to work with. Scenario 1 is disabled for use so remains unchanged and can be used as a reference (e.g. the average national energy use). *Construction* lets the user define his/her house: the kind of house, the contents, orientation, window surface etc. The next three options: *Insulation, Heating equipment* and *Use, behaviour* concern all the energy used for space heating. Figure 5 shows the possibilities the user has to adjust his/her space heating behaviour. When the options heating on in the bedroom is selected, the model assumes a temperature a few degrees below the living room temperature.

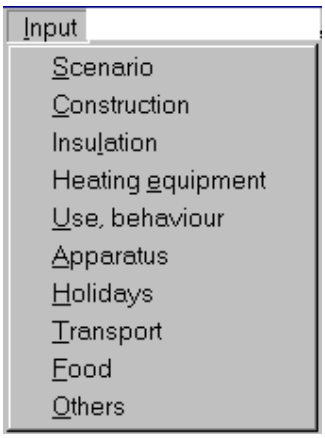

Figure 4: input menu

The *Apparatus* submenu gives the user for 6 household functions (cooling, washing, dish washing, cooking, showering and lighting) the option to select the desirable apparatus or a set of apparatus and the intensity of use. The submenu *Holidays* lets the user select one or more predefined typical holidays. The number of family members joining the specific holiday and the frequency (each year, once in two years etc) should also be entered here. In *Transport* the number of kilometres per transport mode (bicycle, car, train etc.) per year can be entered. These kilometres are exclusive those made for holidays. The window for the *Food* submenu is

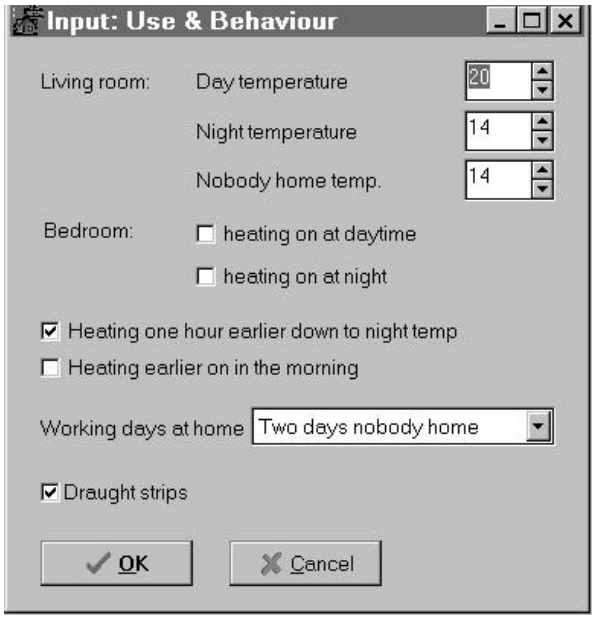

Figure 5: input screen for space-heating behaviour

presented in Figure 6. It shows the options the user has to adjust his/hers food habits. Figure 6 (right hand window) also shows the possibility the user has in almost every window to ask for background information by popping up a second window.

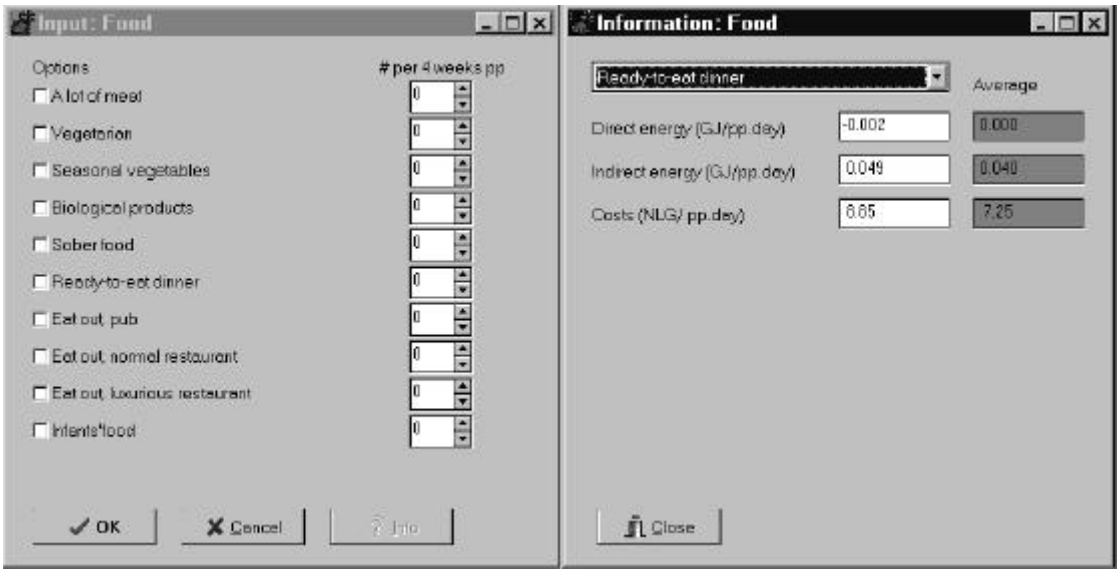

Figure 6: input screen for food options

The default values for food correspond with average national habits. Only variations in habits concerning the evening (hot) meal are available. The other meals are of minor importance from the energy point of view and thus are seen as constant. When selecting one or more options the difference in direct and indirect energy are added or subtracted from the default values. In figure 6, the information window shows that "Ready-to-eat dinners use less direct energy but more indirect energy, the costs are also higher.
The last submenu: *Others* is divided in three categories: Sport, Hobby/go out and Others. Each category contains a set of options the user can select. Examples of these options are: swimming in a heated pool, going to the cinema and keeping pets (dog or cat).

For examining the results and the comparison of scenarios different graphs and a table can be viewed.

Conclusion and Discussion

The relative new environmental science meet some other problems compared with traditional sciences. Its complexity, its societal relevance and the need for new techniques to instruct in a learning-by-doing way. Simulation models and games can perform the role to communicate its complexity, to communicate environmental issues to others than experts and to perform as a learning-by-doing tool.

DoMUS can be a valuable tool for educational purposes. We believe that models like DoMUS can contribute to a better insight in environmental problems and specific for DoMUS the reduction of energy consumption in households.

The focus on energy as an indicator for the impact of households on the environment is one sided although energy is an important one. Energy contains the problem of depletion of finite resources (fossil fuels) as well as the global warming problem. Other possible environmental indicators for household consumption could be: greenhouse gas emissions, the amount of drinking water used or the amount of waste produced.

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DoMUS demo version

A demo version of DoMUS can be obtained from our web-site:
http://www.fwn.rug.nl/ivem/
Click on *software* in the menu in the left frame.
For more information, mail to: r.m.j.benders@fwn.rug.nl